

## Challenges and opportunities for top-down modulation research in cognitive psychology

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### Acta Psychologica

DOI:

<https://doi.org/10.1016/j.actpsy.2020.103118>

Published: 01/09/2020

Peer reviewed version

[Cyswllt i'r cyhoeddiad / Link to publication](#)

*Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):*

Ramsey, R., & Ward, R. (2020). Challenges and opportunities for top-down modulation research in cognitive psychology. *Acta Psychologica*, 209, [103118].  
<https://doi.org/10.1016/j.actpsy.2020.103118>

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**Journal:**

**Title:** Challenges and opportunities for top-down modulation research in cognitive psychology

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Key words: social cognition; top-down modulation; cognitive processes; perception and action; scientific reform and credibility.

## **Abstract**

Studying social modulation of cognitive processes holds much promise for illuminating how, where, when and why social factors influence how we perceive and act in the world, as well as providing insight into the underlying cognitive mechanisms. This is no small objective; it reflects an ambitious programme of research. At present, based on the modal theoretical and methodological approach, we suggest that several challenges exist to achieving such lofty aims. These challenges span an overreliance on a simplistic dichotomy between “top-down” and “bottom-up” modulation, a lack of specificity about mechanisms that renders clear interpretations difficult, and theories that largely test against null hypotheses. We suggest that these challenges present several opportunities for new research and we encourage the field to abandon simplistic dichotomies and connect much more with existing research programmes such as semantics, memory and attention, which have all built diverse research platforms over many decades and that can help shape how social modulation is conceptualised and studied from a cognitive and brain perspective. We also outline ways that stronger theoretical positions can be taken, which avoid comparing to null hypotheses, and endorse methodological reform through fully embracing proposals from the open science movement and “credibility revolution”. We feel that by taking these opportunities, the field will have a better chance of reaching its potential to build a cumulative science of social modulation that can inform understanding of basic cognitive and brain systems, as well as real-life social interactions and the varied abilities observed across the Autism Spectrum.

## 1. Introduction

The idea that what you know influences what you see is not a new one. Indeed, perceptual input is rarely completely encapsulated from other pieces of knowledge or information. While perception is driven "bottom-up" by stimulus features such as object shape, size, and position, perceptions are also influenced from "top-down" by our knowledge of the world. A well-known example is the word superiority effect (McClelland & Rumelhart, 1981), showing that knowledge of words affects perceptions of letters. Our understanding of human perception cannot be complete, therefore, without appreciating how the broader mental context -- including thoughts, beliefs, desires, and expectations, amongst many other factors -- shapes cognitive processes.

Turning to the present focus, top-down and bottom-up influences have also been investigated in social domains – situations that involve interactions between people (for reviews, see Bach & Schenke, 2017; Otten, Seth, & Pinto, 2017; Zeki, 2013). Social information has been shown to modulate how we perceive and judge other people, as well as how we act towards them (Otten et al., 2013). In addition, researchers have started to study the factors that modulate the links between perception and action; situations where visual and motor processes are processed in parallel or integrated somehow, such as during imitation and action observation. Indeed, research has investigated how social factors such as motives, group membership, context, prior experience and beliefs can have a top-down influence on the links between perception and action (for reviews, see Arnold & Winkielman, 2019; Bach & Schenke, 2017; Campbell & Cunningham, 2017; Chartrand & Lakin, 2013; Heyes, 2011; van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009; Wang & Hamilton, 2012). For example, imitative tendencies have been shown to be influenced by group membership (Gleibs, Wilson, Reddy, & Catmur, 2016; Rauchbauer, Majdandžić, Stieger, & Lamm, 2016), beliefs about animacy (Liepelt & Brass, 2010; Klapper, Ramsey, Wigboldus, & Cross, 2014), as well as pro-social primes and gestures (Cook & Bird, 2011; Cracco, Genschow, Radkova, & Brass, 2018; Leighton, Bird, Orsini, & Heyes, 2010; Wang & Hamilton, 2013). To date, therefore, a diverse set of top-down factors have been associated with social modulation and they have been studied across a number of perception and action processes.

As the examples above demonstrate, social modulation has come to encompass a wide range of influences. Indeed, as we unpack in the next sections, the term has a rather

diffuse meaning at present, which is likely to hamper progress. Nonetheless, even with a loosely-defined term, contributions have been made to understanding perception-action links via the investigation of top-down modulation. One piece of added value, for example, is support for the idea that social cognition, as well as cognition more generally, cannot be understood by only studying component processes in isolation (Churchland, 2013). The complexity of social life and related cognition is reliant upon the interaction of many different mental processes (Adolphs, 2010; Frith & Frith, 2012), which requires the study of how signals are integrated within and between processors (Park & Friston, 2013; Bullmore & Sporns, 2009). Therefore, aiming to understand the relationship between social factors and links between perception and action has an intuitive appeal that goes beyond the narrow study of the specifics in question, and generalises to understanding basic processes of human cognition and brain function.

On this analysis, it seems logical and reasonable that social top-down modulation research has garnered broad appeal from researchers in many different aspects of psychology and neuroscience (e.g., Bach & Schenke, 2017; Otten, Seth, & Pinto, 2017; Wang & Hamilton, 2012; Zaki, 2013), as well as those in clinical and health disciplines who study atypical social information processing, such as Autism Spectrum Conditions (e.g., Cook, Barbalat & Blakemore, 2012). Although we feel the current approach has potential to be relevant and important across multiple disciplines, the research programme is in the early stages of development and like any new direction of research it is having teething problems. Indeed, we would argue that it is still finding its feet in terms of understanding its aims and tying those to relevant and rigorous theoretical positions and methodological approaches.

In light of this present context, therefore, in the current paper we aim to present challenges and opportunities for social top-down modulation research that study perception-action links (see Table 1). Although our present focus is on understanding links between perception and action, the set of challenges and opportunities we present are applicable to top-down modulation research in psychology more generally. As such, the general arguments that we present apply equally to studies of social perception and behaviour. We suggest that the most common approaches suffer from several theoretical and methodological limitations, which make it unclear what claims, exactly, are being supported by the evidence provided. These range from ambiguity over what social top-down modulation is and is not, a lack of specificity in the claims being made and a predominance

1 of theoretical positions based on null-hypothesis testing. We outline how and why these  
2 present non-trivial challenges to firmer progress. We then put forward several opportunities  
3 for future research that we feel will help to overcome these limitations and push the  
4 research programme further in the future.

**Table 1.** Challenges and opportunities for social modulation research in cognitive psychology.

	Challenge 1	Challenge 2	Challenge 3
Description	Social top-down modulation needs a clearer definition	Specificity over mechanisms needs establishing	Theoretical and methodological reform is required
Example/s	<ul style="list-style-type: none"> <li>- A neat dichotomy between “top-down” and “bottom-up” is unrealistic and hinders progress</li> <li>- “Social modulation” captures so many factors that we question its utility</li> </ul>	<ul style="list-style-type: none"> <li>- Mechanism vs. stimulus/context specificity is unclear</li> <li>- Research aims are unclear (e.g., basic systems vs. real-life relevance), which makes interpretation of effects difficult</li> </ul>	<ul style="list-style-type: none"> <li>- Testing against the null hypothesis of no modulation dominates and the “crud” factor is a concern</li> <li>- Levels of reproducibility and power are low or not yet demonstrated</li> </ul>
	Opportunity 1	Opportunity 2	Opportunity 3
Description	Replace and avoid unrealistically neat divisions and umbrella terms	Benefit more from established research programmes	Improve theoretical reasoning and embrace methodological reform
Example/s	<ul style="list-style-type: none"> <li>- Describe social factors in concrete and specific terms</li> <li>- Place firmer constraints on generality</li> </ul>	<ul style="list-style-type: none"> <li>- Domain-general knowledge from established literatures (e.g., semantic, memory, attention, and biased competition) are directly relevant and can inform the research programme</li> </ul>	<ul style="list-style-type: none"> <li>- Test alternative theories and predictions beyond the null</li> <li>- Use theory mapping tools</li> <li>- Embrace the “credibility revolution”</li> </ul>

Note: The “crud” factor refers to the notion that to some degree everything is related to everything in psychology. As such, small, non-zero effects are difficult to interpret on their own because they could reflect complex, multivariate and non-theorised relationships (Meehl, 1990; Orben & Lakens, 2019). See section 2.3 of the main text for further details.

## 2. Challenges

### 2.1 *Social top-down modulation needs a clearer definition.*

We find the "social" and the "top-down" part of this terminology a hindrance to the development of the research programme. In the "social" domain, "top-down" currently appears to encompass a broad swathe of factors that could modulate behaviour in many different ways and be supported by many different cognitive and neurobiological mechanisms. Rather than representing a minor quibble over the specifics of a definition, we see the current dichotomic foundational structure as a major challenge to progress for several reasons.

First, at a basic level, it is not entirely clear what counts as top-down. Is it all non-stimulus-driven effects? If so, what constitutes "stimulus-driven" needs defining, and clear boundaries between the two types of modulation need setting. However, our view is that a neat division between top-down and bottom-up is likely to be overly simplistic and unrealistic. Real-life encounters frequently comprise a combination of factors, and while some would typically be "top-down" and others "bottom-up", often it might be impossible to tell. You are waiting for a train and you see a work colleague. What happens next percolates from a complex brew of tonic top-down goals (e.g., get along with colleagues; advance within the workplace; self-promote; avoid conflict) and bottom-up stimulus activation (e.g., who exactly is this colleague?; what interactions have you had with them recently?; what emotional states, if any, does this colleague trigger?). If you were then polite but non-committal to this colleague, would that be a top-down or bottom-up effect?

To answer this question, one could imagine holding the task context constant (waiting for the train), and varying the stimulus factor (the colleague). But this cannot be a complete solution, as in real-world cases, stimulus-driven activity and rich associations between stimuli can lead to implicit task goals; that is, a "top-down" task set could be activated through "bottom-up" stimulus processing. For example, the associations activated from one colleague might in turn activate an implicit goal to approach; sight of a different colleague might lead to the activation of an avoidance goal. Therefore, a framework for studying integration and combination of factors is required. This is not to suggest that manipulating one factor and holding others constant is not an eminently sensible approach



1 to scientific experimentation. Rather, it is to suggest that only attempting to understand  
2 processes by studying them in isolation is fundamentally limited. Instead, processes must be  
3 studied in isolation and in combination to more completely understand how they operate, as  
4 well as approximate their function in real life. In other words, we should estimate the degree  
5 of cognition that results from interaction between systems, such as between processors in  
6 the ventral visual stream and the theory of mind network (e.g., Ramsey, 2018a), as well as  
7 the degree that results from largely localised processing within each of these systems (e.g.,  
8 Kanwisher, 2010).

9         Second, the same term or variants of “social modulation” are used to cover so many  
10 different social factors, which span motives, beliefs, group features and social context (e.g.,  
11 competitive vs. cooperative), that we question its practical value. Indeed, if we stopped  
12 using this umbrella term completely, would we lose anything at all? Under the assumption  
13 that social signals of all kinds could modulate behaviour, could researchers, for example, just  
14 use a more descriptive term to describe the specific social factor of interest, such as a level  
15 of perceived attractiveness, group features or the aspect of the environmental context that  
16 has been manipulated? In fact, rather than losing anything, we may actually gain some  
17 precision by doing so. That is because, until we know otherwise, it is reasonable to suppose  
18 that different social factors may exert influence on perception and action by different  
19 mechanisms. For example, the influence of attractiveness on approach and avoidance  
20 behaviours (Kramer et al., 2020) might arise through very different mechanisms than the  
21 influence of pro- and anti-social interactions on imitation (Wang & Hamilton, 2012; 2013).

22         For these reasons, like others in more general forms of psychology (Awh, Belopolsky,  
23 & Theeuwes, 2012), we suggest that researchers should consider using more specific  
24 frameworks to guide the study of social modulations and biases (see Opportunity 1 below).

## 25 26 *2.2 Specificity needs demonstrating.*

27  
28 A higher degree of specificity is required when making claims regarding top-down control in  
29 relation to the evidence. One pervasive issue concerns stimulus versus mechanism  
30 specificity (Adolphs, 2009). Is modulation specific to a social stimulus or does it reflect a  
31 more general process? This question does not raise doubt over the social stimulus being  
32 social. A face, a group of friends, or a dislike for someone who enters the room, is usually

1 unambiguously person-related and social. Instead, it raises the possibility that the underlying  
2 mechanism that biases behaviour is squarely, or at least predominantly, domain-general and  
3 operates across all contexts to some extent including social settings. If we found that a social  
4 stimulus influenced perception-action links, that does not imply that domain-specific social  
5 cognition had any effect (Ramsey & Ward, in press). An experiment which uses only social  
6 stimuli to show social modulation is susceptible to this argument. For example, visual stimuli  
7 of fingers being raised produce congruency effects on finger-raising responses (Brass,  
8 Bekkering, Wohlschlaeger, & Prinz, 2000), but this does not necessarily imply a social process  
9 of imitation has been demonstrated (Ramsey, 2018b; Ramsey & Ward, in press). It implies  
10 that at some level, the stimulus code given to irrelevant finger stimuli overlaps with the  
11 stimulus code given to the imperative number stimulus (e.g., Hommel, 2009).

12         As further examples, work from our own lab could be viewed differently if a stronger  
13 non-social position was taken (Klapper et al., 2014). Although the work by Klapper and  
14 colleagues (2014) demonstrates clearly that stimulus and belief cues to human animacy  
15 interact to influence behaviour in a social context, it remains unclear if such interactions are  
16 mediated through largely specialised and domain-specific mechanisms or something more  
17 general. In fact, without any specific evidence to the contrary, we now would seek to explain  
18 this effect as domain-general mechanisms of cognitive control operating over domain-  
19 specific social representations (Ramsey & Ward, in press). Likewise, priming a social  
20 construct, such as helping or harming others, can affect stimulus-response compatibility  
21 measures that are purportedly associated with imitative tendencies (Wang & Hamilton,  
22 2013). The default interpretation of such findings focusses on the operation of systems  
23 dedicated to social information processing, rather than more general systems (Wang &  
24 Hamilton, 2013). Interest in highly "social" explanations, such as affiliative goal activation  
25 (Chartrand & Bargh, 1999), motivation to create moral communities (Boehm, 2000), and  
26 active-self models, in which pro-sociality is assimilated into the sense of self (Wang &  
27 Hamilton, 2013) are understandable. These kinds of explanations tap into important ideas of  
28 the moral structure and even the evolved basis of humanity.

29         However, given that powerful workhorses of cognition such as alerting, filtering,  
30 orienting and prioritisation are, by definition, domain-general and operating across social  
31 and non-social contexts (Corbetta, Patel, & Shulman, 2008; Petersen & Posner, 2012; Ptak,  
32 2012; Duncan, 2010), we feel the first hurdle to address is to what extent social modulation

1 effects can be understood in terms of domain-general mechanisms. For example, to what  
2 extent might different kinds of prosocial priming produce an attentional bias towards human  
3 stimuli? In other words, general processes of control that operate through ventral and  
4 dorsolateral frontoparietal cortex could play a much bigger role in modulating links between  
5 perception and action than has been given credit so far (Campbell & Cunnington, 2017;  
6 Ramsey & Ward, in press). That is, when thinking about findings from social modulation  
7 studies, before considering how wide and significant are the potential implications, first  
8 consider how well-studied mechanisms such as attentional bias and shared perception-  
9 action codes might explain the findings.

10         The combined result of this lack of specificity is that the purpose and type of research  
11 being undertaken is unclear. For instance, it is unclear if research is attempting to model  
12 systems and processes to address basic understanding, or estimate effects that have  
13 practical meaning in real-life, or a combination of both aims. Both aims seem possible, but  
14 researchers should be clear on the scope of the work. Being clear on these issues matters  
15 because it directly impacts the type of interpretations that can be made on the data and  
16 how one may evaluate whether the method is appropriate for the purpose. For instance, if  
17 one is trying to draw conclusions about cognitive processes, and we know only that a social  
18 factor has influenced perception and/or action in some way and through some unknown  
19 mechanism, then the lack of mechanism-specificity blurs the interpretation of the effects. As  
20 a consequence, a higher bar needs to be set for what type of evidence demonstrates a  
21 specific claim.

22         Top-down modulation research is not alone in having clear limits on specificity either;  
23 concerns regarding the specificity of claims being made have recently been levelled at a  
24 much more established research programme that is concerned with recognising emotions  
25 from facial movements (Barrett, Adolphs, Marsella, Martinez, & Pollak, 2019). For example,  
26 contrary to the common view in science and society, facial configurations and expressions of  
27 emotion are not uniquely linked. That is, people do not always feel unhappy when they  
28 frown or happy when they smile. Consequently, the observation of a smile alone is not  
29 diagnostic of a particular emotional state. Instead, the evidence to date suggests that there  
30 is a much coarser mapping between facial movements and emotional states, which varies  
31 substantially across people and contexts. One implication of this work is that before firm  
32 conclusions can be made about specific relationships, a higher standard of evidence is

1 required. Another implication is that a lack of specificity is a much more general problem for  
2 cognitive psychology and it may require more general solutions (see Opportunity 2 below).

### 3 4 *2.3 Theoretical and methodological reform is required*

5  
6 Much like psychology research in general (Meehl, 1967; Rouder et al., 2016), alternative  
7 hypotheses appear to default to a null hypothesis – i.e., no top-down modulation. This  
8 seems like a straw man hypothesis, given what we know about “lower-level” processes, such  
9 as vision, which are not completely encapsulated from the influence of other systems. For  
10 instance, neuroscience research has shown that aspects of the visual system, which process  
11 elemental visual properties, such as colour, form and motion, are influenced by systems that  
12 extend beyond the visual system (Gilbert & Li, 2013). If basic components of vision are not  
13 completely encapsulated from the operation of other systems, it seems highly unlikely that  
14 more complex processing units would be. Although the nature of information encapsulation  
15 continues to drive lively debate from a cognitive standpoint (see Firestone & Scholl, 2016  
16 plus the associated peer commentary), we find a strong version of Fodor’s module definition  
17 untenable because it relies, in part, on complete information encapsulation, amongst other  
18 things<sup>1</sup> (Fodor, 1983). Instead, we favour a weaker form of modularity that does not require  
19 complete information encapsulation (Carruthers, 2006; Ogilvie & Carruthers, 2016). Under  
20 such a view, information processing systems are relatively specialised for particular  
21 processes, such as vision, whilst also being modifiable by other systems (Ogilvie &  
22 Carruthers, 2016). What remains, therefore, are questions regarding the extent to which  
23 processes (social or otherwise, top-down or otherwise) modulate perception-action links, in  
24 what situations and by how much?

25       Such questions make considerations of the “crud” factor particularly relevant. The  
26 notion of the “crud” factor was developed in personality research and suggests that to some  
27 (possibly small) degree everything is related to everything, and therefore we should be  
28 especially cautious when interpreting small non-zero relationships (Meehl, 1990; Orben &  
29 Lakens, 2019). Considered in the context of the present focus, given the possibly infinite set

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<sup>1</sup> Fodor’s (1983) definition of a module included fulfilling a range of properties, such as: domain-specificity; information encapsulation; obligatory firing; fast processing; shallow outputs; limited accessibility; innate; fixed neural architecture.

1 of inter-relationships between social variables and cognitive processes, there is a huge space  
2 for small but non-zero relationships to emerge, which prevent a single straightforward  
3 interpretation. Indeed, the results could emerge from a multivariate set of complex and  
4 interrelated causal pathways, which were not considered by researchers (Orben & Lakens,  
5 2019). Here, therefore, crud factor effects are distinguished from effects that reflect  
6 sampling error or noise, which would not be replicable. Instead, crud factor effects are real  
7 in the sense that they are replicable, they are just not interpretable because they reflect  
8 complex, multivariate and non-theorised relationships (Meehl, 1990; Orben & Lakens, 2019).  
9 On this view, we should not be surprised that manipulating social variables could influence  
10 links between perception and action in some way; in fact, we should expect it. As a  
11 consequence, therefore, it seems important to go beyond a comparison to the null  
12 hypothesis and be explicit and clear regarding what alternatives are being considered  
13 (Rouder et al., 2016). Failure to do so will produce a situation that mirrors many other fields  
14 of research: given sufficient power and sensitivity, there is likely to be a non-zero  
15 relationship, but why does it matter? How big is it? Are there credible alternative theoretical  
16 positions? If not, the value of the work remains ambiguous.

17 A further limiting factor on the potential value of the work relates to methodological  
18 reform. Before debates run on for decades regarding social top-down modulation, the  
19 methodological and empirical bar should be adjusted and raised before strong claims can be  
20 made about specificity or any other aspect of social modulation. As pointed out in many  
21 domains of psychology, reproducibility levels are low (Open Science Collaboration, 2015),  
22 which presents a substantial roadblock to the development of a cumulative science, and we  
23 see no reason why top-down modulation research would be any different. In fact, a recent  
24 meta-analysis has shown that the influence of social factors on one purported measure of  
25 imitation is null or negligible (Cracco, Bardi et al., 2018). In addition, other studies using  
26 much larger sample sizes than the original studies have failed to replicate effects of pro-  
27 social primes on imitation (Newey, Koldewyn, & Ramsey, 2019), as well as effects of  
28 emotional expressions and aspects of personality such as narcissism on imitation (Butler,  
29 Ward, & Ramsey, 2015; Darda, Butler, & Ramsey, 2019). Moreover, top-down effects are  
30 likely to be small to moderate in size, much like effects generally in psychology, which  
31 presents a substantial challenge to performing powerful research, but also an opportunity to  
32 change study designs and how one may interpret small effect sizes (see Opportunity 3).

As a counter-point, however, it should be noted that a small but increasing number of studies have used more robust methods (e.g., larger sample sizes, multiple experiments, pre-registration) and show evidence for social modulation (e.g., Cracco et al., 2018; Genschow et al., 2020). Such studies are an encouraging sign for the field, although they stop short of providing evidence that the effects rely on a social or specialised mechanism. As such, it is worth stressing that estimating the presence of non-zero effects in a robust manner does not license an inference about the underlying system controlling such effects. In summary, the need to address methodological reform is clear from these examples and features as one of the main drivers of this special issue.

### **3. Opportunities**

#### *3.1 Move on from “social”, “top-down”, and “bottom-up” terminology and place firmer constraints on generality.*

Researchers may consider avoiding and replacing terms like “top-down” and “bottom-up” (Awh et al., 2012), as they are unnecessary and uninformative under alternative frameworks (see below). Indeed, a host of cues continually fight to dominate attention with many different and varied features providing bias. And we also have a long history of prior experience to add to this picture, which shapes basic perceptual processes. The upshot is that a simple top-down versus bottom-up dichotomy may not be that useful because it is based on an over-simplification, one that mirrors suggestions in other domains of cognitive science regarding the division between automatic and controlled processes (Melnikof & Bargh, 2018). Instead, nearly every situation is a combination of bias from a range of different sources. How they mesh and compete is interesting, but we do not see how vague terms such as top-down and bottom-up remain useful.

It seems simpler to state the specific form of bias – facial attractiveness, level of hunger, motivation to get fitter, addiction to smoking, rather than catch-all terms like top-down and bottom-up. Without clear and specific operational definitions, the terms quickly lose their meaning, especially when there are many different flavours of what people mean by the terms (Lenartowicz, Kalar, Congdon, & Poldrack, 2010; Poldrack et al., 2011). A move

1 towards more descriptive and concrete terminology for social factors also addresses our  
2 concerns about the utility of studying "social modulation" in an abstract sense, when  
3 different social factors may potentially influence cognition in different ways. Such a view  
4 also reinforces recent suggestions that greater progress would be made in psychology if  
5 more descriptive research was performed in general (Yarkoni, 2019), and if there was a  
6 greater willingness to consider functional research, which documents how environmental  
7 features influence behaviour, together with research that aims to understand cognitive  
8 mechanisms (Hughes, De Houwer & Perugini, 2016).

9       To be clear, we are not arguing that no progress at all can be or has been made using  
10 such terms. Existing frameworks do exist where these terms and associated concepts are of  
11 central importance (Bach & Schenke, 2017; Bar et al., 2006; Bar, 2009; Friston, 2010; Otten,  
12 Seth, & Pinto, 2017; Zeki, 2013). On the one hand, therefore, we feel that if one wants to use  
13 these terms then it seems sensible to embed them within these existing frameworks. On the  
14 other hand, however, we offer caution in doing so. As our line of argumentation has put  
15 forward, these frameworks may serve to demonstrate that many domains of psychology and  
16 brain science may suffer from using fuzzy and overly simplified distinctions between bottom-  
17 up and top-down processes. Indeed, we feel the distinction between top-down and bottom-  
18 up, much like divisions between automatic versus controlled processes (Melnikof & Bargh,  
19 2018), can be easily used in non-informative ways. Therefore, the use of such terms may be  
20 a limiting factor in those frameworks also.

21       The predominance of the distinction may hinder progress in other ways also by  
22 unnecessarily shackling the development of alternative frameworks. Other lines of research  
23 could prosper, for example, by taking a different starting point, which favours a multi-  
24 dimensional approach rather than a strong reliance on specifying a neat division between  
25 top-down and bottom-up processes. Research in psychopathology, for example, has shown  
26 that there are benefits from considering questions through a dimensional rather than  
27 categorical lens (e.g., Conway et al., 2019). Under a more dimensional approach, therefore,  
28 one could expect psychological processes, including social modulation, to reflect a continual  
29 blend of multiple sources of bias that interact with each other (Zaki, 2013). Finally, it might  
30 also be worth acknowledging that simple distinctions may have more use in some domains  
31 than others. For example, it seems eminently sensible to use an established framework, such  
32 as object perception (Bar et al., 2006; Bar, 2009), as a template to help guide the study of

1 social perception. Whilst there appear to be clear benefits of doing so, the scope of such an  
2 approach is also likely to be limited. Indeed, such a framework may become less useful when  
3 explaining more complex phenomena, such as modulatory influences in social interactions.  
4 Everyday examples of social interactions serve to demonstrate that neat divisions may need  
5 to be replaced by a default expectation for complex relationships that involve integration  
6 between multiple systems (Zaki, 2013).

7 A companion piece to rethinking terminology is to place explicit constraints on the  
8 generality of reported findings (Simons, Shoda, & Lindsay, 2017). To do so, it is important to  
9 be explicit about the proposed limits, scope and range that the reported effects may have.  
10 Setting proposed boundary conditions on your findings makes it easier for others to attempt  
11 to generalise the findings or challenge and falsify them. For example, do you anticipate the  
12 reported effect to be restricted to a specific social context with a particular individual? Or is  
13 it a more general process that applies to the self in any future situation? Would you expect it  
14 to have obvious social consequences in real life or is the approach more of a demonstration  
15 that targets basic systems? Would you expect the effect to vary considerably across  
16 individuals or contexts? The process of placing clear and obvious constraints on generality  
17 helps to avoid researchers inadvertently mis-specifying a proposal and spending time  
18 needlessly using resources to test it. Placing explicit constraints on generality would be a  
19 valuable addition to clarify the scope and range of expectations regarding social top-down  
20 modulation.

### 22 *3.2 Make better use of developments in more established research programmes.*

24 More established research programmes and frameworks should be harvested much more  
25 for insight and guidance. We should not reinvent the wheel in a social guise. Well-studied  
26 and established frameworks can be particularly informative. For example, non-social top-  
27 down control research in psychology (Theeuwes, 2004; 2010; Awh et al., 2012),  
28 neuroscience (Bar, 2003; Bar et al., 2006; Beck & Kastner, 2009), and neuropsychology  
29 (Humphreys, Riddoch, & Price, 1997) would seem sensible places to start. Elsewhere we  
30 have argued that research in social cognition would benefit from taking as strong a "non-  
31 social" stance as possible (Ramsey & Ward, in press).



1 Frameworks that go beyond top-down control can also be informative because social  
2 cognition is likely to rely, in part, on many of the same general processes that operate across  
3 all domains. For example, proposals from semantics, memory, motor control, and attention  
4 would be valuable in helping to guide expectations and the design of the research  
5 programme. This is especially true if one minimises the expectation for the role of  
6 specialised processes and instead emphasises more general-purpose mechanisms in social  
7 neuroscience (Spunt & Adolphs, 2017; Ramsey & Ward, in press).

8 The semantic cognition literature, for example, supports a division between  
9 representation and control systems in understanding meaning (Jefferies, 2013; Lambon  
10 Ralph, Jefferies, Patterson, & Rogers, 2017). The representation system is associated with  
11 the acquisition and long-term storage of conceptual knowledge and relies on distributed  
12 sensory, motor and affective systems, plus a supramodal hub in the anterior temporal lobes.  
13 The control system utilises this semantic information in line with task- and context-specific  
14 requirements, thus making sure that relevant aspects of knowledge are retrieved and used  
15 at the appropriate time and place. The control system spans ventral and dorsolateral  
16 frontoparietal cortex, thus covering cortical territory predominantly associated with  
17 cognitive control and executive functions (Duncan, 2010; Peterson & Posner, 2012). A  
18 strength of this semantic cognition framework, as well as the key division between  
19 representation and control systems, is that they are based on a host of complementary  
20 approaches and levels of description, which span neuropsychology, computational  
21 modelling, neurostimulation, neuroimaging and comparative work (Chen et al., 2017;  
22 Jefferies, 2013; Lambon Ralph et al., 2017).

23 Translating this semantic framework into the social domain would entail specialised  
24 sensory processors for person features (representation), but general processors for  
25 controlling such social representations (Binney & Ramsey, 2020). Under this view, bias in the  
26 system (e.g., social modulation) can arise from representational and/or control systems and  
27 it is important to be clear which one you are measuring and researchers rarely, if ever, do  
28 this in cognitive psychology or neuroscience studies (including perception and action  
29 coupling). As reviewed recently (Campbell & Cunnington, 2017), this is particularly relevant  
30 for some perception and action links, which rely heavily on inferior frontal and parietal  
31 cortices, because these brain regions are implicated in both social processes (e.g., Rizzolatti  
32 & Sinigaglia, 2010) and domain-general attentional processes (e.g., Duncan, 2010). As such,

1 on a brain network level of description, functional and anatomical specificity would need  
2 demonstrating.

3 A further general framework to consider how to conceptualise social modulation is  
4 biased competition (Desimone & Duncan, 1995; Duncan, Humphreys, & Ward, 1997; Beck &  
5 Kastner, 2009). Biased competition models offer a way to conceptualise how signals from  
6 different processing components may be integrated. Such frameworks characterise the brain  
7 as a complex information processor that has many specialised processors operating in  
8 parallel. For example, in the visual domain, there are dedicated processors for form, motion,  
9 colour, as well as complex feature combinations. Examples outside of the visual domain  
10 include processors largely dedicated to memory, planning, and a range of executive  
11 functions. Parallel processing systems of this sort present a computational problem,  
12 however, which concerns how signals are integrated across processors. Indeed, for coherent  
13 behaviour, the activity of different information processors and associated neural networks  
14 must be coordinated so that a single object or event guides response effectors at any one  
15 point in time. Behaviour would become disorganised and ineffective, for example, if goals,  
16 such as meeting a friend at the train station, could not integrate with other signals such as  
17 remembering which platform and at what time your friend is due to arrive. Likewise,  
18 behaviour would also breakdown if sensory signals, such as the sounds and visual inputs of  
19 trains arriving and departing, overwhelmed and interfered with other cognitive processes,  
20 such as your current goal to meet your friend.

21 Biased competition frameworks solve the problem of signal integration by allowing  
22 bias for an object or event in one processor to propagate through the network until it  
23 resolves on a “winning” object or event. Such competition is meant to operate in ubiquitous  
24 fashion across the entire brain, and therefore would integrate neural activity within and  
25 between the neural networks associated with person representation and control processes.  
26 Within a biased competition framework, therefore, social modulation can be treated like any  
27 other form of bias, whether it takes a social or non-social form. Indeed, a given type of bias  
28 is not special in any sense, but instead just reflects another form of bias in the system. This  
29 offers the opportunity to integrate multiple signals – both social and non-social – without  
30 the need to worry about hard-to-define terms and possibly unrealistically strict divisions  
31 between concepts like “top-down” and “bottom-up”.

Turning to another established literature, we consider how learning and memory systems can add to understanding social modulation. Given that memories and prior social experiences shape perceptions, it seems equally valuable to harness insight from memory research (Amodio, 2019). Amodio (2019) makes clear that social cognition research can benefit in numerous ways from considering the knowledge obtained about learning and memory systems across decades of research spanning multiple methods, as well as species, culminating in thousands of studies. For example, learning and memory research in cognitive neuroscience has identified several forms spanning episodic, semantic, instrumental and aversive conditioning, as well as habit. These forms of learning and memory rely on different neural networks and each one can link to multiple response channels (e.g., planning, impressions/judgments, affect, action and avoidance). Rather than largely ignoring this literature, it makes sense to exploit it in relation to social modulation research as it would appear to make clear, obvious and relevant predictions regarding different aspects of social cognition.

In terms of demonstrating specificity of the claims being made, extensive solutions have been put forward by authors in another social domain (emotion perception from faces) that are extensive and not only relate to specificity, but reliability and generalisability (Barrett et al., 2019). A detailed description of the specific solutions proposed is beyond the scope of this article, but it remains clear that such guidance exists and the importance of not engaging with such issues is clear. In short, if older and more established research programmes could benefit from such proposals, it seems reasonable that principles of specificity (in multiple forms), reliability and generalisability are worth considering in relation to newer research programmes such as top-down modulation in perception-action coupling.

Many other existing frameworks could also be of considerable value; here we just present a few illustrative examples of possible ways forward. The more general aim for the programme would be to avoid the danger of remaining encapsulated from these domains of human cognition and brain research, as they seem relevant on many levels and the differences may have been exaggerated in the past.

### *3.3 Improve theoretical reasoning and embrace the credibility revolution.*

1 To alter the default position, researchers could seek alternatives to the null hypothesis. In  
2 the case of underlying systems, for example, researchers could probe the extent to which  
3 social modulation reflects bias between representational systems (e.g., different person  
4 representations biasing each other) or, alternatively, if it reflects a form of failure in control  
5 systems. Control systems allow cognition to maintain a task-relevant focus. Priming from  
6 irrelevant stimuli can therefore reflect a failure, perhaps a very mild failure, of control  
7 systems to maintain task-relevant activity. As we hope is obvious, social modulation arising  
8 from an inability to exert complete task-relevant control would lead to a different type of  
9 interpretation regarding the functional value of the modulation when compared to  
10 modulation arising from bias in a person representation system such as face, body, affective  
11 or theory of mind representations.

12 To illustrate how research questions can be moved on in this way, consider Bach and  
13 Tipper (2007), who found that visuomotor compatibility effects (e.g., the relative ease of  
14 pressing a foot-switch when responding to an image of a footballer as compared to an office  
15 worker) could influence social attributions. In their case, a stimulus person would be  
16 perceived as more athletic if associated with the footballer-footswitch stimulus-response  
17 pair. A question arising is, does this effect demonstrate a functional capacity, by which  
18 statistical associations in the environment are used to a maximum degree, or does this  
19 reflect some leakage, or failure of control, in properly insulating task-specific processing  
20 from irrelevant information? Tipper and Bach (2008) later investigated this further to find  
21 that in fact the effect is likely based on a failure of control, a misattribution of the self's  
22 visuomotor fluency to the actor. Of course, bias could operate in both representational and  
23 control systems as well as between these two systems. Addressing such theoretical  
24 positions, no matter what the outcome, would inform the type of mechanism underlying  
25 bias and give an insight into the functional relevance and value.

26 Another complementary approach to improving theoretical development would be  
27 to use tools that aid theory exposition. In order to clarify theoretical positions and aid  
28 cleaner and more efficient comparisons between perspectives, researchers could consider  
29 using the newly developed theory mapping tool (Gray, 2017; [www.theorymaps.org](http://www.theorymaps.org)). Theory  
30 mapping in this way enables researchers to express their theoretical position in a visual form  
31 using a common set of symbols. Given that the topic in question is complex, such an

1 approach may be one way to help reduce mis-characterisation of other people's positions  
2 and the subsequent testing of mis-specified alternative theories.

3 If we change gear and consider the "credibility revolution" that is taking place in  
4 psychology (Vazire, 2018), much has been written about the issues associated with low  
5 reproducibility and the need to embrace methodological reform (Chambers, 2017; Simmons,  
6 Nelson, & Simonsohn, 2011; Open Science Collaboration, 2015; Munafò et al., 2017;  
7 Ramsey, 2020). To enhance the quality of the evidence provided, researchers interested in  
8 how perception-action links can be biased by social signals need to raise the bar for what  
9 counts as convincing evidence for what top-down modulation is and why it is relevant. There  
10 have been many sensible suggestions put forward for how and why to embrace open science  
11 using more rigorous methods, which we encourage social modulation researchers to  
12 embrace (Chambers, 2017; Munafò et al., 2017; Vazire, 2018; Zwaan, Etz, Lucas, &  
13 Donnellan, 2017).

14 Rather than repeat these very sensible prior suggestions, here we will focus on one  
15 specific issue that we see as particularly important for social modulation research, but which  
16 is likely to apply across the board in psychological science. Given that the anticipated effects  
17 are likely to be modest, a first basic aim would be to show that an effect is reliable, in the  
18 sense that it replicates with an acceptable degree of precision. Also, and of particular  
19 relevance to social top-down effects, it would make sense to consider the extent to which  
20 such effects have the potential to accumulate over time (Funder & Ozer, 2019). That is, the  
21 measurable effect (bias) produced by social signals (i.e., top-down modulation) in a one-off  
22 instance may be small, but if that is likely to be experienced 20 times a day, 5 days a week,  
23 then real-life effect and consequence may be different. For example, if you work alongside a  
24 colleague who you find attractive or you work in a cooperative/competitive context, the  
25 effects of each social episode may add up to something more than the one-off exchange.  
26 Not only that, such effects may only be measurable after longer exposure, which brings up  
27 questions about dose-response that also seem relevant. This of course would need to be  
28 demonstrated empirically with either longitudinal work or work that measures how effects  
29 modulate over time with repeat exposures to the same social modulation. It also reinforces  
30 the recent suggestion that basic research in brain science could benefit from engaging with  
31 research in real-world settings, so-called real-life neuroscience (Redcay & Schillbach, 2019;  
32 Shamay-Tsoory & Mendelsohn, 2019).

#### **4. Conclusion**

In conclusion, we argue that research aiming to understand how social factors modulate links between perception and action face several challenges that limit progress. To combat these challenges, we outline opportunities to reform the research programme. Opportunities include rethinking an overreliance on simplistic and unrealistic dichotomies (e.g., “top-down” vs. “bottom-up”), learning from more established research programmes, such as semantics, memory and attention, as well as embracing proposals for theoretical and methodological reform emanating from the “credibility revolution”. We feel that taking these opportunities seriously will provide a springboard for the emergence of a cumulative science of social modulation that can inform understanding of basic cognitive and brain systems, as well as real-life social interactions and the variety of abilities observed across the Autism Spectrum.

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